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U.S. AIR FORCE'S AERIAL SPRAY MISSION: SHOULD THE DEPARTMENT OF DEFENSE CONTINUE TO OPERATE THIS WEAPON OF MASS DISPERSION?

By

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ABSTRACT

The Air Force currently operates three C-130 special missions. One of its special missions the aerial spray mission operated by the 910th Airlift Wing at the Youngstown Air Reserve Station in Ohio is the subject of this research. The research question is whether the Department of Defense should continue to operate this specialized operation, or should it be outsourced to commercial sources. This research investigates the many advantages and disadvantages of the military aerial spray program and compare the results to the benefits and hindrances of two private aerial spray companies. Another criteria used is an overall cost assessment to compare the sole military source to both civilian companies, and determine which organization is the most cost effective. The scenario to evaluate the cost criteria was a standard aerial spray mission performed at Minot Air Force Base, North Dakota. Both sources possess their own significant advantages and disadvantages to conduct aerial spray operations. It was determined that private aerial applicators can provide aerial dispersion services at a more economical price than the military source. The analysis found that, although military aerial spray is more expensive than contracted aerial spray, a military aerial spray capability should still be retained to conduct spray operations in a deployed environment and for emergency response following national disasters.

INTRODUCTION

The United States Air Force (USAF) aerial spray mission has been a unique, but common practice since 1973. This mission involves spraying for disease-carrying pests over Department of Defense (DoD) installations and anti-foliage operations on bombing ranges to decrease inadvertent brush fires and to expose unexploded ordnance (UXO) after bombings. The program also maintains a stand-by readiness capability using oil dispersing agents to neutralize open-water oil spills, and vector control over metropolitan areas after a natural disaster. The latter capabilities can only be executed by the President of the United States (POTUS) after disasters or emergencies. Currently, the aerial spray mission is operated out of the 910th Airlift Wing at the Youngstown Air Reserve Station in Ohio.[1]

The Air Force has had a monopoly in aerial spray operations over DoD installations and cities after natural disasters. This authority of military spray comes at a considerable cost to taxpayers and alternate options like civilian spray should be considered. In addition to high cost, there are other recent developments further taxing DoD aerial spray. Non-compete laws like the Stafford Act, Economy Act and Anti-Deficiency Act (ADA) have been legally challenging the Air Force following recent major spray applications over major cities and bodies of water. The commercial spray sector may be able to deliver a more effective and efficient spray operation than the DoD approach. A persistent ambiguity exists in the structure of DoD aerial spray. Since it is a special mission without direct support from a sister federal agency like other special mission units, operations are requested and planned starting from the 910 AW then coordinated to Air Force Reserve Command (AFRC) and Air Mobility Command (AMC). For example, aerial firefighting is allied with the United States Department of Agriculture (USDA) and weather reconnaissance is paired with the National Oceanic and Atmospheric Administration

(NOAA); 910 AW spray has no partnership. This lack of structure has caused organizational discontent and confusion within the spray program. Finally, the spray mission tests the operational availability of a unit with limited aircraft. Operating out of a single-squadron unit with only eight aircraft makes mission prioritization difficult, especially when units are tasked to deploy for expeditionary missions outside the continental United States (OCONUS).

Several Air Force leaders are proposing ways to further promote the DoD aerial spray program at the 910 AW. Leaders from the 910 AW to AMC have considered developing a National Spray Plan (NSP) to advocate for modernizing the spray fleet, procure newer spray modules, and to align the program with a federal agency for better organization. There has also been discussion to extend DoD aerial applications to regions outside the United States to help combat vector-borne disease and aid in maritime oil spills. These possibilities and several more could help justify the Air Force retaining aerial spray regardless of cost.

The purpose of this research is to determine if the Air Force should retain the aerial spray capability or if a more effective method to conduct aerial spray exists. To determine the outcome of this research, I incorporated a seven-tiered outline structure. Several criteria were presented to compare the Air Force aerial spray mission and that of commercial sources utilizing the Evaluation Framework. Throughout the evaluation I compared the overall costs associated with a DoD operated aerial spray process against those of commercial applicators. A breakdown of total costs of an Air Force spray operation was compared to one that could be contracted by the government, while contrasting the total value each conveys to the customer. An assessment of the advantages and disadvantages of each spray capability was also examined to further justify the argument of my research. The results of each measurement method were then analyzed to reach recommendations and a conclusion for the Air Force aerial spray program.

BACKGROUND

Aerial spray capability was developed in the early 1920s to aid in fertilization and pesticide application over farm fields to produce a better crop.[2] On 3 August 1921 in a joint effort between the U.S. Army Signal Corps in Dayton, Ohio and the U.S. Agriculture Department, John A. McCready piloted an Army Air Service Curtiss JN4 "Jenny" to spray lead arsenate on a field near Troy, Ohio to kill catalpa sphinx caterpillars.[3] This first test of spraying agents from a moving aircraft, or "crop dusting" as it was originally called, was a major success and the process of aerial spray was founded.[4] Since the early days of crop dusting, the practice of aerial spray has progressed into anti-foliage applications, usage as a fire retardant, seed dispersion, and oil dispersion with future potentials constantly being considered among the civilian and government sectors. It has advanced into a lucrative business in the agricultural community with more than 1,300 commercial businesses treating over 70 million acres of cropland each year.[5] The practice of aerial spray is not only limited to the civilian sector; it has also been incorporated into the DoD as a C-130 Hercules special mission classification.

DoD C-130 Special Missions

C-130s have three special mission operations in the Air Force. The 53rd Weather Reconnaissance Squadron (WRS), 403rd Airlift Wing, Keesler Air Force Base, Mississippi. Better known as the "Hurricane Hunters". The 53rd WRS flies specially modified C-130J aircraft to survey tropical storms and hurricanes in the Atlantic Ocean, the Caribbean Sea, and the Gulf of Mexico for the National Hurricane Center.[6] The Modular Airborne Fire Fighting System (MAFFS) Program operated by the 302nd Airlift Wing, Peterson Air Force Base, Colorado. The MAFFS Program consists of one Air Force Reserve unit and three Air National Guard units to aid the United States Department of Agriculture Forest Service (USDAFS) in

aerial firefighting missions.[7] The Modular Aerial Spray System (MASS) Program operated by the 910th Airlift Wing (910 AW), Youngstown Air Reserve Station, Ohio. The 910 AW is tasked by the DoD to operate the only large area fixed-wing aerial spray capability in the DoD for insect control, vegetation elimination, and oil spill dispersion.[8] This research will focus on the 910th Airlift Wing aerial spray program.

Air Force Aerial Spray and its Missions

Air Force aerial spray began in 1947 with the UC-123K spray aircraft in an effort to reduce troop loss due to vector borne disease outbreaks.[9] Since its inception at Langley Air Force Base, Virginia, it has transferred from several units until it found a permanent location at the 910 AW, Youngstown Air Reserve Station in Ohio. Throughout its evolution, the program has settled into a standard annual spray plan that involves spraying for mosquitoes and biting sand midges in such DoD installations as Minot Air Force Base, North Dakota and Parris Island, South Carolina. Insect control applications are not only directed to control overwhelming nuisance pest populations, but also to prevent the diseases they may carry, including the West Nile virus and several forms of encephalitis.[10] Herbicide applications are applied at bombing ranges such as the Utah Training and Test Range (UTTR) and Saylor Creek in Idaho for vegetation elimination to prevent inadvertent brush fires, and so explosive ordnance disposal (EOD) personnel can more safely locate and detonate unexploded ordnance (UXO).[11] Some recent examples of major aerial spray missions by the 910 AW include mosquito control over New Orleans, Louisiana and Southeastern Texas after the flooding aftermath of Hurricanes Katrina and Rita in 2005. In 2009, the 910 AW was also the first to respond to the Gulf of Mexico to conduct aerial spray for Operation Deepwater Horizon, a mission utilizing oil

dispersants to help neutralize an oil spill after the British Petroleum (BP®) drilling platform explosion.

Specialized DoD Aircraft

The program incorporates specialized aircraft, equipment, and personnel to operate the aerial spray special mission. Since 1986, the Air Force has utilized the Lockheed C-130 aircraft to conduct spray missions, and currently uses six specially modified C-130H2 airframes.[12] These aircraft are not solely used for spray mission. Their main mission is tactical airlift, but they can be configured for aerial spray in about 75 minutes. The process of specializing a C-130 for spray involves affixing a specially built spray boom that connects from the MASS on the interior of the aircraft through a two-inch hole in the aft hatch doors on each side. The booms extend six feet out of the aft doors with 2 – 30 individual spray nozzles each, depending on the agent being dispersed.[13] All modifications to the C-130 to make it a special-mission aircraft are accomplished at the 910th Maintenance Squadron's (910 MXS) Aerial Spray Flight (ASF), 910th Maintenance Group (910 MXG), 910 AW by spray-dedicated maintainers. The Air Force Reserve Command is currently aiming to modernize the capability with the procurement of ten C-130J models for the 910 AW for future missions.

Specialized Equipment

To conduct aerial spray missions at low altitudes, specialized liquid containers were developed to fit specifically into a C-130; this system is called the Modular Aerial Spray System (MASS).[14] There are six types of MASS altogether: one is used exclusively for training with water, two are ultra-low volume systems and three are what is known as a normal system, each

with four-500 gallon main tanks and a 250 gallon flush tank. The ultra-low volume system (ULV) is used specifically for aerial pesticide dissemination because of the relatively small amount of product needed to spray for nuisance insects over a vast area. The ULV system is attached to a boom with eight to 30 nozzles on each side, depending on the entomologist's specifications; it delivers .03 gallons of fine-mist pesticide per minute. Applications that require massive amounts of liquid herbicide to neutralize cheatgrass and other fire-prone, invasive vegetation on bombing ranges will use the normal spray system. Cheatgrass is an invasive, non-native grass that rapidly spreads in agricultural producing farm fields throughout the United States; it can reduce some crop yields by 33%.[15] Oil dispersing missions will also use the normal system due to the large amount of dissolving agent required to neutralize a crude oil slick over an open body of water.[16] The normal system is attached to a boom with only two larger bell nozzles that will deliver up to 300 gallons per minute.

The MASS is designed to fit only one system per aircraft. The spray system is loaded onto a C-130 using another specially-developed, 20-wheeled vehicle known as a 60K Tunner loader, or K-Loader. The MASS rests on hundreds of rollers on the K-Loader and is then slowly rolled onto the aircraft by spray maintainers and C-130 loadmasters, taking about one-hour until it is in place. The MASS consists of four interconnected tanks with three pumps per module (15 horsepower for herbicide and 5 for pesticide) which is operated by a specially-trained load master from an analog control panel on the forward of the MASS.[17] The current system is over 20 years old and ASF maintainers claim the MASS is in need of a replacement due to aging technology, inefficient pump rates, and severe internal corrosion. The 910 AW is currently working with local congressional representatives to procure new MASS equipment to meet future spray demands.

Specialized Personnel

Because of its unique capability, specialized personnel must also be employed to operate the spray program. Twelve aerial spray maintainers make up the ASF, including seven full-time Air Reserve Technicians (ART) and five Traditional Reservists (TR).[18] All ASF personnel must first advance through the MXS in a primary Air Force Specialty Code (AFSC) before they can become a spray maintainer. These members are responsible for the development, maintenance, and repair of everything associated with the MASS, including the spray boom and nozzle elements, pump, and inner mechanics of the system.[19] MASS parts are fabricated and fitted internally at the 910 MXS.

Two ART and two TR entomologists are also employed at the 910 AW. Entomologists work with the Environmental Protection Agency (EPA) and collaborate with the USDA Center for Medical and Veterinary Entomology (CMAVE) to develop and conduct pest control methods using military aerial assets. 910 AW entomologists are responsible for research and investigation of pest insects that carry vector-borne diseases, and the most effective ways of eliminating them in particular areas of the United States.[20]

Five specially trained aircrew make up the flying segment of the spray program: a pilot, co-pilot, navigator, flight engineer, and a loadmaster. These spray aircrew operate out of the 757th Airlift Squadron (757 AS), 910th Operations Group (910 OG), 910 AW.[21] Aircrew must maintain currency specific to this special mission in addition to their regular tactical airlift and airdrop currencies. Aircrew may soon have the ability to operate the spray mission 24-hours per day. In September 2013 the 757 AS was directed by AFRC to develop a night time aerial spray program, utilizing night vision goggles (NVG), to specifically target vector-borne carrying pests that operate mainly at night.[22]

In addition to specialized personnel to handle the hazardous chemicals associated with aerial spray, medical personnel are also required to perform a special blood test. All spray personnel are tested annually for a nerve transmitter known as cholinesterase.[23] A cholinesterase test, conducted by the 910th Medical Squadron (910 MDS) nursing staff, will alert personnel if they have been exposed to toxic levels of organophosphates found in pesticides and insecticides.

Specialized Process

Aerial spray applications must be performed at extremely low altitudes to effectively deliver a particular spray agent and to avoid excessive spray drift. Insect and herbicide treatments are dispensed at 150 feet above ground level (AGL) while oil dispersant application is accomplished at 300 – 500 feet AGL.[24] A typical insect control application utilizes anywhere from 0.5 to 1.0 ounce of pesticide or larvicide per acre of area sprayed; this equates to a mist particulate smaller than one microgram (1 mcg).[25] Some forms of pesticide and larvicide used by the Air Force include Dibrom, Duet, and Aqua Anvil; herbicide treatment involves spraying Krovar, Round-up Pro Herbicide, and Panoramic; Corexit 9500 is used for oil dispersion.[26] In order for the aircrew and ground crew to evaluate and gauge aerial applications, all products are dyed the color blue with products such as sodium fluorescent dye and Uvitex OB.[27] A C-130 spray sortie consists of a standard back-and-forth pattern across the area to be covered, utilizing visual flight rules (VFR), or aerial dead-reckoning, and the blue-colored dye as reference points.[28]

Date	Location	Target Pest	Chemical	Acres	oz/ acre	gal/ acre[1]	Gal total
22-25 OCT 13	PARRIS ISLAND,SC	MIDGES	DIBROM	6,534	0.75		40
4-15 NOV 13	SMOKEY HILL, KS	MUSK THISTLE	MILESTONE	3,415		7	23,904
10-21 MAR 14	UTTR (HILL AFB)	VEGETATION	KROVAR	1,396		22.5	29,294
31 MAR-2 APR 14	PARRIS ISLAND,SC	MIDGES	DIBROM	6,800	0.68		40
5-9 MAY 14	PARRIS ISLAND,SC	MIDGES	DIBROM	7,500	0.85		47
27 MAY-6 JUN 14	WILLISTON ACE	MOSQUITO LARVAE	VECTOBAC	4,184		5	20,357
1 JUNE 14	GRAND FORKS AFB	MOSQUITO LARVAE	ALTOSID	912		2	1,845
16-20 JUNE 14	MINOT[2]	MOSQUITOES	TRUMPET	5,813	0.9		41
24-27JUN 14	JB CHARLESTON	MOSQUITOES	TRUMPET	17,980	0.85		120
30 JUN-3 JUL 14	GRAND FORKS AFB	MOSQUITOES	TRUMPET	11,625	1		90
14-18 JULY 14	MINOT[2]	MOSQUITOES	TRUMPET	25,947	0.9		210
17 JUL 14	WILLISTON WATFORD	MOSQUITOES	ZENIVEX	34,875	0.32		160
28 JUL-2 AUG 14	HOMESTEAD, ARB[2]	MOSQUITOES	DIBROM	30,000	0.5		120
25-29 AUG 14	HOMESTEAD, ARB[2]	MOSQUITOES	DIBROM	26,902	0.45		120
2-3 SEPT 14	CRANEY ISLAND	MOSQUITOES	DIBROM	7,837	0.5		45
6-8 SEPT 14	JB CHARLESTON	MOSQUITOES	TRUMPET	17,763	0.85		120
15-26 SEPT 14	MOUNTAIN HOME, ID	CHEAT GRASS	PLATEAU	2,927		7	19,793
			TOTALS	**212,410**			**96,346**

Figure 1. FY2014 Aerial Spray Missions. A typical spray schedule including the type of pest targeted, product used, and amount used per mission. (Adapted from Lt Col Drew Tancer, 757th Airlift Squadron / Director of Operations to Air Force Reserve Command / A3OO, FY 14 Aerial Spray Annual Report (1 Oct 13 – 30 Sep 14). Memorandum, 1 November 2014)

Civilian Aerial Spray

More than 1,300 businesses throughout the United States offer aerial spray / crop dusting services[29]; this study will focus on two companies for comparison – Dynamic Aviation from Bridgewater, Virginia and Vector Disease Control International (VDCI) located in Little Rock, Arkansas. Both companies are established in the aerial spray community and have worked in conjunction with 910 AW on several national operations.[30]

Dynamic Aviation

In addition to charter and intelligence, surveillance, and reconnaissance (ISR) operations, Dynamic Aviation provides an aerial spray capability to both government and private organizations.[31] Beginning in the early 1930s, it has developed into a global operation with over 140 aircraft in 18 locations around the world.[32] Its aerial spray capability includes applications

for mosquito and vector control, mating disruption, fire suppression, and oil spill dispersant.[33] Dynamic Aviation conducts its aerial spraying with a fleet of specially designed Beechcraft King Air aircraft; more specifically, the King Air A90 airframe. The King Air A90, the smallest of the 90 series Beech aircraft, is a twin-engine turboprop with a normal takeoff / landing weight of around 9,000 pounds (lbs).[34] It is 35 feet long, 14 feet high and has a total wingspan of 45 feet with a maximum range of about 1,000 nautical miles (NM) while carrying its useful load of 4,000 lbs at a cruise speed of 204 knots (kts).[35] Dynamic Aviation has modified the King Air A90 with more than 40 different spray systems to optimize the cabin space.[36] These modifications and capabilities have enabled a fleet of A90s to cover nearly 450,000 acres in one night.[37] Dynamic Aviation has been contracted by local, state, and federal governments to eradicate mosquitoes after Hurricanes Katrina and Rita, oil spill management following the BP® Deepwater Horizon platform explosion, and invasive pest control in U.S. national forests.

Vector Disease Control International (VDCI)

Unlike the multi-spray capabilities of Dynamic Aviation, VDCI specifically focuses on mosquito control services to small towns, large cities and counties throughout the United States.[38] It also has the ability to provide services to private residences, commercial businesses and several countries OCONUS.[39] VDCI is a relative newcomer to the aerial spray community. It was founded in 1992 as a regional company, spraying in areas around the Little Rock, Arkansas area, but have since blossomed into a multi-state corporation.[40] VDCI primarily conducts its aerial spraying with a fleet of specially modified Piper Seneca aircraft. The Seneca is a twin-engine turboprop with a normal takeoff / landing weight of around 4,750 pounds (lbs), nearly half as much as Dynamic Aviation's King Air A90.[41] It is 29 feet long, 10 feet high and

has a total wingspan of 39 feet with a maximum range of about 830 NM while carrying its useful load of 1,300 lbs at a cruise speed of 200 kts.[42] VDCI utilizes advanced optimization technology on its aircraft to ensure the most efficient delivery is executed for maximum mosquito control.[43] Similar to the 910 AW and Dynamic Aviation, VDCI has been commissioned to provide emergency mosquito control services in the aftermath of hurricanes, flooding and vector-borne disease outbreaks.

This contextual information served several purposes: a background of civil and military aerial spray, the type of spray missions associated with a DoD and civilian operation and the capabilities each organization has to execute its respective missions. It was found that there are many similarities to Air Force and civilian spray capabilities, such as spraying for disease carrying pests after natural disasters, but there are also many differences, including aircraft payload and methods employed. The data gathered will enable a thorough review of the advantages and disadvantages of each capability.

METHODOLOGY

Several factors were examined to compare Dynamic Aviation, VDCI and Air Force spray. The evaluation investigated the benefits and challenges based on equipment and means of conducting business and a cost analysis associated with sustaining a standard spray operation. These criteria were selected because they can be more objectively weighted for an analysis. Following the comparison, an analysis of the findings was conducted to reach a conclusion of whether or not the Air Force should retain the aerial spray mission.

Advantages of USAF Aerial Spray

Spraying for insects or invasive vegetation from the air has many advantages over ground-based applications, however, governmental spray operations conducted by the Air Force and private spray businesses each offer their own advantages and disadvantages. One of the principal advantages to USAF aerial spray is its established ability to operate over DoD installations. Since the military's first aerial spray operation in 1947 to combat disease-carrying insects, AF assets have had the advantage of flying over restricted military airspace. Commercial sources cannot be granted access through military airspace unless it is for an in-flight emergency or are granted a prohibitive airspace pass several months in advance, and even these passes are restrictive.[44] This is may seem like a simple hurdle for a contracted aerial spray, but it would require significant changes to stringent military no-fly zones across the United States. And with the current level of potential terroristic threats, such requests by private businesses would be difficult, if not impossible, in order to protect military assets and confidentiality.

Ample airspace for training and further development of the spray program is another advantage of DoD aerial spray. The home of the DoD's only fixed-wing aerial spray program, the 910 AW, shares a tower, runways and airspace with the Youngstown-Warren Regional Airport (KYNG). According to updated Federal Aviation Administration (FAA) Title 14, Code of Federal Regulations (CFR), Part 139, KYNG is a Class I airport[45]; however, with only one regularly scheduled commercial airline that conducts business at the airport four-times per week and a small fixed based operation (FBO), the airspace is relatively unfettered. In addition, it is equidistant from Cleveland Hopkins International Airport (KCLE) and the Pittsburgh Airport (KPIT) (about 60 miles), placing KYNG in a low congestion zone. This categorization and

placement between KCLE and KPIT in low congested airspace provides the 910 AW and the 757 AS with near unlimited space for flight training. On average, KYNG only encounters about 40,000 passengers in and out of its terminal each year, as compared with around 8 million each for KCLE and KPIT.[46] The Camp Ravenna Joint Military Training Center, controlled by the Oho National Guard, is also only 20 miles from the 910 AW. Camp Ravenna offers more than 21,000 acres the 910 AW can use upon request to conduct realistic tactical airdrop missions and aerial spray training flights with water.[47] Although ample airspace and a nearby military training facility are beneficial to the DoD capability, Dynamic Aviation boasts its own training returns that rival the DoD's, which is discussed later.

Another attribute that could support the DoD aerial spray argument is its established national emergency track record. Since its transition to the USAFR, the Air Force spray mission has conducted ten non-military emergency deployments, spraying over 7 million acres to battle crop-devastating pests and disease-carrying insects after natural disasters.[48] Some examples include a 1973 mission in Panama to spray for mosquitoes carrying Equine encephalitis, a 1987 mission to combat Dengue fever in Puerto Rico, mosquito control following Hurricane Floyd in North Carolina and Virginia in 1999, and its most recognized operation, mosquito control following the aftermath of Hurricanes Katrina and Rita in Louisiana and Texas. Flooding conditions after such disasters, coupled with warm temperatures and high humidity provided an ideal breeding ground for biting and disease-carrying insects. Following aerial spray applications in these areas, bites from nuisance insects dropped 91%; from 10 – 200 bites per minute to less than one in some of the 22 sites covered.[49] The Air Force spray program has had significant results while battling vector and nuisance pest populations, but again, both VDCI and

Dynamic Aviation were both heavily involved in similar operations after national emergencies. There accomplishments will be discussed shortly.

Aerial spray has been in demand during modern war. Malaria, spread by mosquitoes, has been an incessant problem for American soldiers since the first U.S. military expedition to a tropical region. "During World War II Allied Forces in the Pacific theater suffered more casualties from malaria than from enemy action, and solving this problem became a major objective of Allied commanders."[50] In 1943 the Army Air Force (AAF) in cooperation with the Bureau of Entomology and Plant Quarantine developed an aerial-dispersal apparatus to spray dichlorodiphenyltrichloroethane (DDT) to kill malaria-carrying mosquitoes in Pacific combat zones. Since this inception, the use of military aerial spray has been a common practice in tropical areas of the world where the United States is conducting expeditionary operations. Although U.S. civilian aircraft spray in many countries that are non-hostile to the United States, it would be difficult and dangerous for a commercial aerial spray company to conduct spray missions in a combat zone. At such low altitudes and without effective measures against anti-aircraft weapons equipped on its aircraft, a civilian company could not conduct spray in combat areas.

The size of the payload and the range of the C-130 is an advantage over the aircraft used by its commercial counterparts. A standard C-130H is 98 feet long, 39 feet high and has a total wingspan of 133 feet with a maximum range of about 1,000 NM while carrying a maximum normal payload of 36,500 lbs. at a cruise speed of 318 kts.[51] When equipped with the MASS, a C-130H can carry 2,000 gallons of liquid spray agent and still be under its maximum payload limit, providing an even greater range (at least 1,300 NM).[52] When compared to the maximum liquid capacity of the modified King Air A90 by Dynamic Aviation, 425 gallons and 1,000 NM,

and that of the customized Seneca used by VDCI, 250 gallons and 830 NM, the C-130H dominates in total capacity and range.

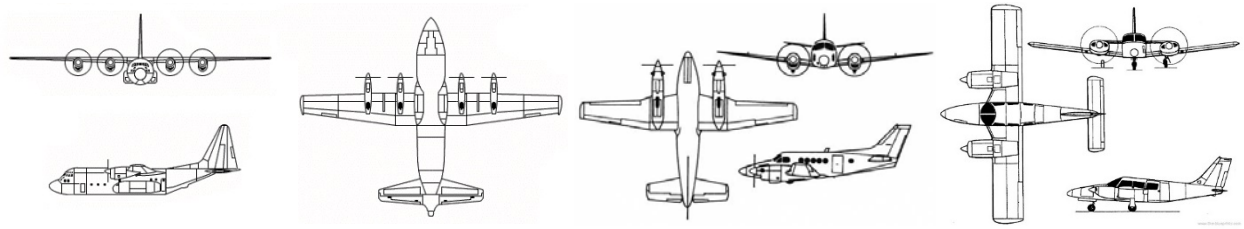

Figure 2. C-130 (910 AW), King Air (Dynamic Aviation) and Seneca (VDCI) illustration. (Adapted from http://www.the-blueprints.com/blueprints/modernplanes/)

Disadvantages of Air Force Aerial Spray

With the many advantages of DoD aerial spray, come several disadvantages that could potentially make contracting the capability out to a commercial source more advantageous; including cost, which will be covered later. One of the main difficulties of conducting a specialized Air Force aerial spray mission is its competition with the standard mission of the unit, tactical airlift. After force reduction implementations in 2009, the 910 AW lost four of its sixteen original aircraft. Another force reduction in 2014, decreased the airframes by four more and eliminated the 773rd Airlift Squadron (773 AS), leaving the 910 AW with eight aircraft and only one flying squadron, the 757 AS. This reduction has put a strain on not only the flight crews that manage both missions, but also, on the distribution and prioritization of the flying hours allotted by HQ AFRC and missions each year. Further complications arise when the unit is tasked with an Air Expeditionary Force (AEF) deployment rotation. A typical C-130 AEF airlift package consists of three aircraft and a spare (4 aircraft) and four total crews, or 24 personnel, to fly the missions (8 total pilots, 4 navigators, 4 flight engineers, and 8 loadmasters).[53] In addition to tasking aircrew and aircraft, an AEF rotation would also require maintenance personnel to deploy, reducing the number of experienced maintenance personnel

qualified to work on modified spray aircraft and spray equipment. An AEF deployment would leave the home-station unit with only four aircraft to perform its usual tactical airlift operation and conduct its standard, yearly spray plan. A typical spray mission includes two aircraft and one chase plane with personnel and equipment. Such a dilemma with an AEF rotation and a typical spray mission would obligate seven aircraft, leaving only one C-130 at home-station for scheduled maintenance and training missions. In a situation such as this, a contracted spray source has greater availability because it does not have an AEF responsibility.

Aerial spraying also stresses airplanes. Flying at extremely low altitude puts severe strain on the frame of a C-130, causing faster attrition and more frequent maintenance. The effective flying hours (EFH) of an aerial spray C-130 flying at altitudes of 150 – 300 feet AGL is about three-times the EFH of an aircraft flying at normal altitudes.[54] The dilemma of quicker accumulation of EFH causes more frequent programmed maintenance depot (PDM) visits at Robins Air Force Base, Georgia, which takes the aircraft away from the 910 AW more often. Faster occurring PDM schedules not only puts an additional strain on normal missions, but it also directly increases costs to the Air Force for the extra maintenance cost associated with PDM and the cost to transport the aircraft to and from Robins AFB. Commercial sources typically own and operate their maintenance facilities on location, causing less of a burden on fluidity of operations. Also, low altitudes are less strenuous on the lighter aircraft employed by contractors.

Advantages of Contract Aerial Spray

One of the greatest advantages to commercial spray is the competition with other companies in a free market to determine the most cost efficient service. Private sector businesses may already have an advantage over government sources because of their competitive nature, but

to ensure progress of the free market Congress passed the Economy Act of 1932. The Economy Act permits the federal government to purchase goods from other federal agencies only if the goods or services cannot be provided by a commercial source less expensively, and if said goods or services are in the best interest of the U.S. government.[55] This act prevents monopolization of federal services on the civilian market and enables commercial companies to profit by providing goods and services to consumers. The Economy Act is valuable to companies like Dynamic Aviation and VDCI which can potentially provide a cheaper spraying capability for the federal government; however, during times of natural disasters there exist laws that insist on immediate federal assistance. After the POTUS declares an emergency after a natural disaster, insecticides and oil dispersants may be applied within the United States as Defense Support of Civil Authorities (DSCA) operations to mitigate the public health or economic effects of the disaster; this is known as the Stafford Disaster Relief and Emergency Assistance Act (Stafford Act). [56] The Stafford Act's intent is to offer temporary federal assistance to state and local governments to alleviate suffering and damage caused by natural disasters.[57] It is also the intent of the Stafford Act to transfer emergency services like vector control and oil dispersion over to the private sector once immediate response has been rendered.[58] The Stafford Act paves the way for contractors to render services at a better cost.

Commercial spray sources have the ability to conduct research and development (R&D) more readily than the Air Force. Since the Air Force operates its sole spray capability from a single base with a set budget, it is limited to the scope of advancements it can make to the spray mission. A commercial source relies on advancements to its spray operations to continue improving its capabilities. This encourages companies like Dynamic Aviation and VDCI to invest more capital and incorporate more advanced technology into its spray mission to make it

more cost competitive against its rivals. Both companies continually re-invest into its capabilities through R&D and technological advancements; Dynamic Aviation returns approximately 23% of its profit and VDCI 17% to R&D.[59, 60] The Air Force spray flight is limited to a small operations and management (O&M) budget from the National Defense Authorization Act (NDAA) allocation that has been steadily declining in recent years.[61]

The 910 AW may have many advantages in its ability to train, but commercial spray businesses boast several of their own training enhancements. For instance, Dynamic Aviation operates out of a privately owned airport called Bridgewater Airpark (KVBW) in Virginia. Known as an "aviation technology zone", KVBW sits in a secure location away from heavy air traffic on more than 200 acres of open land to readily test spray equipment and techniques.[62] It has a diverse landscape of mountainous geography to the north and west (Appalachian Mountains) and level terrain to the south and east. This diversity in geography enables Dynamic Aviation to conduct a more varied training program than the 910 AW site that sits on a level landscape of a constant 1,100 – 1200 feet above sea level. KVBW is also equidistant (100 miles) from the two nearest major airports, Dulles International Airport in Washington D.C. and Richmond Airport in Richmond Virginia with limited air traffic in between. Additionally, it has more than 150,000 square feet of facilities "to operate its modern maintenance and modification center, equipped with the most advanced machining and avionics equipment."[63] VDCI does not operate out of a large aerial industrial complex like Dynamic Aviation, but they do have over 40 satellite locations throughout the United States.[64] This extensive national structure gives VDCI a wide-ranging expertise in not only differing landscapes, but also climates, altitudes, and regional requirements (e.g. invasive grasses in the Midwest to nuisance insects in the Southeast). Again,

these variations provide a contractor such as VDCI a more diverse capability than its DoD counterpart.

Commercial sources have a well-established track record following natural disasters. Civilian crop dusting was developed and employed long before military aerial spray programs, and thus, have more experience operating in more diverse environments. Some of the most diverse and demanding spray application are spraying after environmental and/or manmade disasters. Dynamic Aviation has more than 50 years of spraying experience, with over 100 million acres covered over hurricane ravaged cities and oil-covered bodies of water.[65] Some of its most recent accomplishments include a vector control response to a West Nile Virus (WNV) epidemic in Colorado and South Dakota in 2003, the Gulf Coast hurricane response after Hurricanes Katrina and Rita in 2005 and a spring flooding response in Kentucky in 2011, as requested by the Kentucky Department of Agriculture.[66] After a 2010 application in Massachusetts to combat the Eastern Equine Encephalitis Virus (EEEV) transmitted by mosquitoes, entomologists concluded that mosquito populations diminished by 90%.[67] More specifically, no mosquitoes sampled after the intervention were infected with EEEV.[68] These results are comparable to those reported by the 910 AW after similar applications in the Gulf Region; 91% Air Force versus 90% commercial.

Another benefit that commercial sources have over a federal competitor is the ability to partner with another commercial source. Dynamic Aviation is in partnership with Clarke chemical and VDCI is affiliated with Anvil, two common and effective insecticides sprayed over many cities in the United States. The association with chemical companies enables aerial spray contractors to advertise their businesses, furthering their spray enterprise, turning a bigger profit and developing advanced potentials.

One final benefit commercial aerial spray possesses is its ability to spray at night. Both Dynamic Aviation and VDCI utilize military grade ANVIS-6 night vision goggles (NVG) to operate at night, a more preferred method by a consumer when there are less people outside and mosquitoes are less mobile. The use of NVG gives the private sector the advantage of spraying 24-hours per day for a more effective and faster mission completion. The Air Force spray mission is in its infancy of conducting nighttime aerial spray operations. Initial NVG spray training just began in July 2014 and the first NVG pesticide operation was conducted in April 2015.[69] The Air Force has yet to perform a large-scale aerial spray mission with the sole use of NVG, while its civilian counterpart has been practicing the nighttime method for over ten years.

Disadvantages of Contract Aerial Spray

Compared to military operations, the civilian sector is significantly less encumbered by the limitations that hinder the Air Force; however, some hurdles still exist for contract aerial spray. One of the main hindrances to civilian spray sources is the inability or difficulty to obtain a special flight authorization waiver to operate in special use airspace that are coded as restrictive or prohibited. Special use airspace is an aerial boundary wherein activities must be secure from non-DoD entities due to the sensitive nature of events occurring at that particular military installation.[70] There are two types of special use airspace: regulatory and nonregulatory.[71] Nonregulatory airspace includes warning areas, military operations areas (MOAs), and controlled firing areas (CFAs).[72] Nonparticipating, civilian traffic flying under instrument flight rules (IFR) can be granted access through this airspace if IFR separation can be provided by the air traffic controller (ATC)[73]; therefore, civilian aircraft can operate through nonregulatory airspace fairly easy. Prohibited and restricted areas fall under the regulatory category that

strictly prohibits civilian aircraft from flying through its defined dimensions for protection of U.S. national security interests.[74] Restricted and prohibited airspace include military areas that harbor aerial gunnery, guided missiles and nuclear weapons and technology. "Penetration of restricted areas without authorization from the using or controlling agency may be extremely hazardous to the aircraft and its occupants."[75] According to many aerial spray aircrew from the 757 AS, even military aircraft are subject to strict scrutiny while operating in restricted airspace. In an interview with Lt Col John Kochansky, Chief of Spray, he emphasized this point stating, "We have had some close-calls while spraying over King's Bay Naval Submarine Base. All it takes is some young Marine with an itchy trigger finger and we are dead."[76] This is in reference to tight security at King's Bay due to its nuclear submarine mission and the Marines that protect the base. These demands highlight the obstacles contracted aerial spray could face while operating over certain military installations; a common occurrence for Air Force spray mission.

The amount of payload civilian aircraft employ could also be considered a disadvantage compared to the Air Force. Dynamic Aviation's modified King Air A90 can only carry 200 – 425 gallons of insecticide per sortie, depending on the weight of the agent being used. This limited capacity in addition to the smaller spray breadth of the King Air with its fuselage spray nozzles attached (total extension = 22 feet apart from port to starboard) and rate of spray (100 gallons per minute) limits the total area that can be covered in one sortie. VDCI's Seneca has an even larger handicap, with a maximum payload of 250 gallons, a total extension of 18 feet apart and 90 gallons per minute spray rate. The capacities of Dynamic Aviation and VDCI dwarf that of an Air Force spray-modified aircraft. The 910 AW's spray C-130s disperse insecticide at a total of 30 feet apart from nozzle tip to nozzle tip, while capable of carrying over 2,000 gallons and spraying at a rate of 300 gallons per minute. Adding the C-130s more extensive range, it is

evident that a C-130 would be able to cover more area with less swaths than either of its civilian counterparts.

Cost Considerations

The total cost per mission between the Air Force and commercial spray sources could be the deciding factor to determine if the Air Force should retain the aerial spray capability, or if contracting the spray mission is a more logical option. Several criteria were used to compare the overall cost of an aerial spray operation by both groups: the cost to operate the aircraft, the cost of manpower and ancillary costs (i.e. lodging, per diem and vehicle rentals). The setting for the cost assessment is a three-day pesticide mission over Minot Air Force Base, North Dakota, a typical yearly Air Force spray operation that covers about 60,000 acres of the base and surrounding areas (Williston). Once all costs are compared, a final evaluation was analyzed to determine recommendations and conclusions.

The Cost of a Typical Air Force Spray Mission

A standard C-130 spray mission from the 910 AW costs $9,500 per hour ($8,000 per hour in a normal airlift configuration); this sum is the cost to fly the aircraft including fuel.[77] Two aircraft are utilized for such a mission; one primary spray aircraft, and one spare. It takes each C-130 six hours to fly from the 910 AW to Minot AFB and back, which is 12 hours altogether, equaling $114,000. The primary spray aircraft will fly two sorties at two hours each for one day, equaling four hours for a cost of another $38,000. The total cost to operate the aircraft on this mission is $152,000.

Standard manpower consists of two crews of five aircrew members (10 altogether), another 10 maintenance personnel and two entomologists. For this research, each member of the Air Force spray mission is on Title 10 Reserve Personnel Appropriation (RPA) status for each day of the mission. An RPA is an order that puts the member in an active military status for the period the order covers.[78] In this scenario, the 910 AW aircrew, entomologists and maintainers are each on a three-day RPA, which equals 66 days of RPA orders. The average cost of an RPA for an enlisted member is $175 and the average cost for an officer is $325. Six officer aircrew and two entomologists consist of 24 RPA orders for this mission, totaling $7,800. The four enlisted aircrew and ten enlisted maintainers consist of 42 RPA orders, totaling $7,350. The total cost of manpower for this mission is $15,150.[79]

The lodging rate for this trip is $130 per day for the 44 nights lodging is required (the day of arrival and the night of the spray mission). The total cost to lodge all 22 TDY personnel is $5,720. The full per diem rate for Minot, N.D. is $57 per day per person for one day, and partial per diem for the two travel days is $34 each day. The total cost of per diem is $2,750. Finally, five vehicles were rented for this TDY. Each vehicle costs $33 to rent each day for a total of 15 rental days (5 vehicles x 3 days) for a total cost of $495. The total ancillary costs equals $8,965.

The three-part cost of an Air Force spray mission of this size totals $176,115.

The Cost of Contract Aerial Spray

For an aerial spray mission the size of Minot AFB, Dynamic Aviation would employ five King Air A90 aircraft with two 100-gallon tanks each. Three would be active aircraft and two are reserved as spares. Due to the weight of Dibrom, the preferred pesticide for this type of operation, the spray-modified King Air would each only be able to carry 200 gallons, instead of

its maximum load of 425 gallons. Spraying at 0.75 ounces per acre, Dynamic Aviation can cover 20,000 acres in one sortie. At this rate, three pilots would be required to fly consecutive sorties to manage all 60,000 acres.

A typical contract for a Dynamic Aviation customer quotes an operation such as Minot AFB at $1.84 per acre, this includes the cost of operating the aircraft ($1,060 per hour)[80], and pilot pay (average $16 per hour), and cost of Dibrom (censored due to its confidential contract with Clarke Chemical Co.).[81] Since commercial operators can spray at night, the mission would continue throughout the night; therefore, no lodging, per diem or rental vehicles are necessary. The total cost for this mission equates to $110,400.

Using the smaller Piper Seneca, VDCI would also employ five aircraft with the ability to carry only about 120 gallons of Dibrom each. Four aircraft are actively used while one is reserved as a spare. Spraying at a rate of 0.75 ounces per acre, VDCI would require one and a half sorties to cover 20,000 acres. Pilots for VDCI would have to fly nearly twice as many sorties as their civilian counterpart and more than ten-times that of the Air Force to cover the total area.

A typical contract for a VDCI customer quotes an operation of this scale at $1.98 per acre, including the cost of operating the Seneca aircraft ($250 per hour)[82], and pilot pay (average $15 per hour), and cost of pesticide ($5,000).[83] One barrel of pesticide costs about $5,000 and will cover about 60,000 acres. VDCI also possesses NVG capability, so they are able to spray continuously until all 60,000 acres are swathed. The total cost for a VDCI-contracted mission equates to $118,800.

RESULTS

Table 1. Evaluation of Advantages versus Disadvantages

Comparison 1	Aircraft Range	Payload	Size of Operation	Years of Experience	AEF Ability	Emergency Experience	Training
DYNAMIC AVIATION	(-)	(-)	+	+	(-)	+	+
VDCI	(-)	(-)	+	(-)	(-)	+	(-)
AIR FORCE	+	+	+	+	+	+	+

Table 1. *Continued*

Comparison 2	Effective-ness	Availability	Strain on Aircraft	Economy & Stafford Act	Operation Diversity	NVG Capability	DoD Operability
DYNAMIC AVIATION	+	+	+	+	+	+	(-)
VDCI	+	+	+	+	(-)	+	(-)
AIR FORCE	+	(-)	(-)	(-)	+	(-)	+

Table 2. Cost Comparison

	Operational	Manpower	Ancillary	Total
DYNAMIC AVIATION	+	+	+	$110,400
VDCI	+	+	+	$118,800
AIR FORCE	(-)	(-)	(-)	$176,115

ANALYSIS OF RESULTS

Evaluation of Advantages and Disadvantages

Commercial and Air Force spray capabilities share some advantages and disadvantages, but there are some that are more significant than others. The Air Force commands some major advantages over its civilian counterparts. The ability to operate over restrictive and prohibitive airspace more readily, safer and more controlled operations in a combat environment, and larger payload are some of the benefits the Air Force possesses over contract aerial spray. The Air Force also holds many inconveniences that hamper its ability to operate aerial spray. The spray mission puts additional burdens on the tactical airlift mission of the 910 AW, especially when the

unit is tasked with an AEF deployment. Also, flying at extremely low altitudes for sustained periods of time puts severe stress on the airframe of a C-130, requiring more frequent maintenance and PDM schedules.

Contract aerial spray shares some of its own advantages and disadvantages. Commercial aviators have been flying with the aid of NVG for over ten years, providing its customers a quicker result by operating 24-hours a day. Private industry is protected by the Economy and Stafford Acts. These policies assure that the federal government will use commercial services over other federal organizations to uphold free enterprise. Also, a company like Dynamic Aviation has the advantage of its own private airpark in a geographically diverse area, providing the company with a comprehensive training environment. Commercial sources have some disadvantages, as well. Private aircraft are severely limited in the categories of airspace they can operate in that military aircraft are able to more readily. It could be difficult, dangerous and potentially impractical for commercial spray to operate in restricted military zones. Also, the payload of contracted spray is significantly inferior to that of the Air Force. Commercial companies require considerably more sorties and aerial passes during large-area spray missions than the Air Force C-130.

Based upon gathered data of benefits and weaknesses of each capability, Dynamic Aviation and the Air Force shared an equivalent amount of advantages. VDCI, although maintaining an extensive capability, has a limited training structure and does not have the large-area spray proficiency as its civilian counterparts. VDCI is better utilized as a small-scale, regional spray operation.

Cost Analysis

A basic breakdown of costs involved in both DoD and contracted aerial spray capabilities were explored using a standard, large-area mission. A comparison of all three organizations concluded that there was similarity between civilian companies, but a stark difference between the civilian companies and the Air Force. At $118,800 for VDCI, $110,400 for Dynamic Aviation and $176,115 for the Air Force, it was determined that the contracted spray sources were the most economical solution for an operation this size. From this research, as predicted, it was found that Air Force spray costs about 33% more than commercial operations.

RECOMMENDATIONS

Each organization offers its own advantages and adversities and each organization utilizes its strengths and weaknesses to perform successful and proficient spray missions for a variety of purposes. Contract spray is obviously the more economical option; however, because of the many unique advantages inherent to the Air Force spray mission, it was recommended the DoD retain the spray capability with some modifications to ensure its survivability.

The 910 AW should continue to pursue modernizing its C-130 fleet and update its aging MASS to meet future needs. Updating military aerial spray will not only enable more efficient CONUS operations, but it will make it a more effective operation in a combat environment – a responsibility civilian spray cannot perform. Further development of the 910 AW spray mission could also help establish peaceful, OCONUS missions to disperse pesticides in developing nations. An important, future operation of the 910 AW could be eradicating diseases such as West Nile Virus and Malaria through its aerial spray program.

A greater proficiency with NVG will also need to be realized to ensure its military spray endurance. Regulations by the EPA and USDA are encouraging spray operations, both civilian and military, to operate at night to lower the risk to humans and agricultural animals. If the 910 AW cannot master nighttime spray at low altitudes, it could severely hinder the mission to the point where the program could be grounded and retired.

Like its special mission counterparts, the 910 AW should partner with a sister federal organization to develop a more robust support structure. One way to fulfill this vision is to develop a National Spray Plan (NSP) in cooperation with the EPA, USDA, and FEMA. A NSP could help organize the military spray mission into a more efficient and effective resource.

Finally, the DoD must acknowledge the benefit of operating aerial spray in tandem with its civilian counterparts. A joint military-civilian spray operation could serve several purposes, but two present more than others. It could potentially save the DoD millions of dollars over a decade, and subsequently allocate more funding toward the tactical airlift mission of the 910 AW. Also, it could establish a contractual relationship with private aerial spray companies, so when the 757 AS is tasked with an AEF deployment, contract aerial spray could intervene until the unit returns.

CONCLUSION

Throughout the evolution of the US military, many changes have constantly taken place to make way for the next generation of resources, to curtail unnecessary expenditures or for the overall betterment of the service. In this research, the aim was to determine if the DoD should retain the unique aerial spray mission, a special mission category, operated by the 910 AW. The argument for this research was that there were many hindrances to operating an aerial spray

operation by the Air Force. Some of the major drawbacks is that the mission draws human and materiel resources away from an already limited tactical airlift operation, and it requires additional manpower and funding to sustain. It is also an expensive special mission to operate. In addition to extra manpower and O&M funding, the program requires specialized MASS equipment that impose a large immediate investment and continuous maintenance. Finally, military aerial spray costs about 33% more than a private company to conduct. Because of its sole-source status and the cost to operate specially-modified C-130 aircraft over low altitudes, the aerial spray mission is more costly than operating a standard airlift mission. Even with its costly detriments, there still exists some strong suggestions to preserve the mission. Due to the importance of aerial spray operations in a combat environment and its ability to stand-up and execute national emergency operations as declared by the President, it was determined that the DoD should retain this unique capability. In this case, the significant potentials of the aerial spray mission outweigh the pecuniary cost of operating it; therefore, the spray mission should stay in the Air Force. This endorsement cannot sustain in status quo, however. The 910 AW should adhere to the recommendations outlined in this research to ensure it can operate efficiently and to the needs of the military and general American populace.

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